unaided eye. There is therefore abundant room for a large variation in the navigator's estimate of the motion of the cloud.

The editor of the Pilot Chart says:

The statement to which Mr. Quinn calls attention was made with full knowledge that it was in opposition to the generally accepted theories of an eastward drift at high altitudes in the Tropics. It is, however, in accordance with the observations upon which the major portion of my hurricane article is based, namely the Greenwich mean noon observations returned by the voluntary meteorological observers afloat and cooperating with this office. These agree in showing that in the vicinity of the West Indies and during the hurricane season the motion of *what they call the upper clouds* is from a point between north and east, while the motion of *what they call the lower clouds* is from a point between south and east. It may be that the navigators did not properly distinguish between upper and lower clouds, or that they, on rapidly moving vessels, were unable to detect the slow eastward drift of the lofty cirrus. But inasmuch as my article was written for their benefit, and with the hope that it might prove of practical value to these observers in time of need, it seemed wise to adopt their system of classification and to present the phenomena as they appeared to, and were recorded by, the men for whom I was writing. It did not seem wise to attempt to explain to them that what they were in the habit of calling upper clouds were not upper clouds at all, or that the motion which they had recorded as taking place from the east was really in the opposite direction. It would probably have been safer to have based my statements upon the facts recorded by trained observers at regular meteorological stations. I may do this in future editions of the article, and at the same time request the mariner to see and record the facts as they really are rather than as they appear to be. Definite instructions to the voluntary meteorological observers at sea were first issued in 1901, prior to which time, and in some cases subsequently thereto, the cloud observations were signally lacking in accuracy.

My own analysis of the frequency of cloud motions during hurricane months, as observed at Belen College, Havana, gives the following figures:

Clouds.	Number of observations.	Percentage of frequency of movement from—			
		NE.	SE.	SW.	NW.
Upper.........	645	23	8	39	30
Lower.........	650	44	34	15	7

Mr. Page's analysis of the Havana observations shows that there is a very respectable percentage of upper cloud movements from the east. The extensive studies made by Professor Bigelow (see MONTHLY WEATHER REVIEW for April, 1904) show that great variations occur in the level that separates the upper westerly from the lower easterly movement. It may be quite possible that observers, both on land and sea, are unable to distinguish the altitude of a cloud by means of its appearance, and that so-called cirrus clouds are below the normal altitude as frequently as they are above it. It may be that cirrus clouds actually occur in the lower stratum as well as in the upper. The Editor observed continuously with his marine nephoscope on the island of Barbados and in its vicinity, during the cruise of the *Pensacola* in February, 1890, and found true cirrus clouds moving in a variety of directions between northwest and southwest and with a great variety of velocities. We should never forget that cirri and cirro-cumuli often form at the boundary between two layers of wind; the movement of the cloud is the resultant of the action of the two winds, and does not represent the actual motion of either nor the motion of any very important thick layer of air. The clouds simply move within the thin layer of mixture that separates the two more important masses.

Again, there can be no doubt that ascending masses of northeast trade wind and descending masses of southwest return trade frequently come into contact or collision, especially during the warmer part of the day, each obstructing the other's progress. As we approach the equator all tradewind motion from the northeast gradually dies away. It can, therefore, happen that at points considerably removed from the equator the obstructed winds, rising and carrying their clouds with them, may produce the phenomenon of cirrus clouds from the northeast, while below these the descending winds may carry light cirrus clouds from the west. It seems likely that this phenomenon would occur most frequently on the northerly border of the track of a hurricane.

The more we consider the question here under discussion, the more convinced we must be of the great importance of improving and extending the methods and observations of the whole system of cloud observations on land and on sea.—*C. A.*

THE DISSEMINATION OF DAILY FORECASTS BY TELEPHONE.

By WM. G. BURNS, Section Director, Springfield, Ill., dated June 27, 1904.

The rapid development of telephone service in the Middle West, especially in the rural communities, has opened up a great field for the dissemination of the daily weather forecasts. This effective means was recognized over a year ago, and attention was invited to the fact in the Annual Report of the Illinois Section for the year ending June 30, 1903. While the development of the service in this section does not yet show altogether satisfactory results, arrangements are now under consideration whereby it is believed the information will be made available for 250,000, or more, telephone subscribers in small towns and rural districts.

The census of 1900 has credited Illinois with 264,000 farms, fully one-half of which, it is believed, are now supplied with telephones. The work of building new lines and connecting the different exchanges is rapidly progressing, and information has been received that one telephone supply house alone is furnishing new material in that direction at the rate of $500,000 a year.

A convention of State telephone managers was recently held in Springfield, Ill., and opportunity was afforded to address the body on the subject of cooperation. It was represented that all progressive exchanges maintained an information operator, and as the weather and its changes formed a vital subject of interest to the rural communities, the information operator would not be well equipped without this intelligence. It was further stated that in extending the telephone service the fact that the weather information would become available to its subscribers, would often be the determining factor in inducing an irresolute farmer to enroll. The facts presented were well received and active cooperation was promised. It has been planned to offer the service to telephone exchanges, and then notify the public through the press that the information is available.

Under the growing operation of connecting the exchanges into one vast homogeneous system, it will not be necessary to send telegrams to all, but, by careful selection of well located centers, a large territory may be covered by relaying the information from one exchange to another.

The following extract from the Copper Country News, Calumet, Mich., of June 21, 1904, shows that the plan which Mr. Burns advocates in Illinois has been approved in Ohio and Kentucky.

The extent to which the Weather Bureau is appreciated and utilized by the farmer is exemplified by the fact that the Cincinnati and Suburban Telephone Company has made an arrangement with the Weather Bureau in Cincinnati by which the farmers in surrounding counties in Ohio and Kentucky are enabled to get the daily morning forecast of the weather almost as soon as it is made.

The plan is to have the forecast telephoned immediately after its making to the central exchange in Cincinnati, which in turn will telephone it to the local exchanges in eight counties. These are to give out the information to the patrons in those places free of charge.

ATTEMPTS AT METHODICAL FORECASTING OF THE WEATHER.[1]

By LOUIS BESSON.

[Translated by Miss R. A. Edwards.]

At the present time scientific forecasting of the weather is

[1] Annuaire de la Société Météorologique de France, April, 1904, pp. 92–97.

based almost exclusively on the study of the daily synoptic charts, but it is not necessarily true that the process of local forecasting, based on the observation of meteorological instruments and the aspect of the sky, has lost all interest. Many persons possess a barometer and consult both it and the weather vane assiduously. In places that do not subscribe for the dispatches of the Central Meteorological Bureau, and that receive too late the papers that publish them, local observations constitute the one basis possible for the establishment of forecasts. Finally, in case a knowledge of the weather is gained from the analysis of synoptic charts, will it not be possible to perfect this knowledge, in making a forecast for the day, by means of local data recorded at the first morning observation?

It has appeared interesting to me to attempt to determine: (1) Precise rules for the utilization of the usual meteorological observations in forecasting weather at short range; (2) the degree of success that can be attained in the application of these rules.

I have restricted the problem to the forecasting of rain, and have considered, to the present time, only the winter season, that is, the months of December, January, and February.

The meteorological elements that I have considered are six in number; namely, barometric pressure, direction and velocity of the wind, temperature, and cloudiness, observed at 9 o'clock in the morning, and finally, the variation of pressure from 6 to 9 o'clock in the morning.

I propose to determine the degree of probability of rain (or snow), before midnight, according to the values of these six elements, taken the morning of the same day.

For this purpose I have taken the statistical records founded on twenty-one years of observations at Montsouris. Omitting the cases where it rained or snowed at 9 o'clock in the morning, 1546 days remained, representing $\frac{818}{1000}$ of the total number of days of observation. In considering the velocity of the wind I have been able, because of breaks in the anemometer records, to use the observations of only 945 days. I will limit myself here to a brief summary of the results obtained; they will be found explained more in detail in an early number of Annales de l'Observatoire de Montsouris.

Height of the barometer.—The probability of rain varies inversely as the pressure: from $\frac{86}{100}$ for a pressure of 742 millimeters it falls to $\frac{19}{100}$ for a pressure of 777 millimeters; nevertheless, from 747 millimeters to 752 millimeters it maintains practically the same value, $\frac{43}{100}$, and appears to increase a little for very decided heights of the barometer (more than 777 millimeters). It is $\frac{50}{100}$ for 763.5 millimeters. Consequently, if one possessed no other data than the pressure in making the forecast for the day, it would be safe to predict rain every time that the pressure, at 9 o'clock in the morning, was less than 763.5 millimeters, and, in the contrary case, no rain. This rule, applied to the 1546 days observed, was correct 64 times out of 100.

Barometric variation from 6 to 9 o'clock.—We may say, in general, that the probability of rain diminishes when we pass from an area of low pressure to an area of high pressure, but the variation of this probability is rather irregular: from $\frac{81}{100}$ for a fall of 15 millimeters it becomes $\frac{40}{100}$ for a rise of 0.5 millimeter, then remains almost stationary, between $\frac{37}{100}$ and $\frac{42}{100}$, when the pressure increases. For decided rises, it clearly increases and appears to rise above $\frac{50}{100}$. In forecasting rain when the variation is algebraically more than —0.3 millimeter, and fair weather in the contrary case, we will be correct 59 times out of 100.

Direction of the wind.—The probability of rain is minimum ($\frac{15}{100}$) when the wind blows from the east-northeast; it is maximum ($\frac{75}{100}$) when it blows from the west-southwest, that is, from a point diametrically opposite. From east-northeast to west-southwest by way of south the probability increases in a progressive and regular manner; from west-southwest to west it falls abruptly to $\frac{55}{100}$ and gradually decreases to $\frac{24}{100}$ at the north, and presents at the north-northeast a secondary maximum of $\frac{33}{100}$. In predicting rain only when the wind blows between south and west, one will be correct 67 times out of 100.

Velocity of the wind.—The chances of rain increase very regularly with the velocity of the wind. From about $\frac{25}{100}$ in perfect calm, the probability becomes $\frac{83}{100}$ for a velocity of from 8 to 9 meters per second. In case of greater velocity the probability seems to diminish. In all cases where the wind has been more than 9 meters we find only $\frac{75}{100}$ of rain. The value $\frac{50}{100}$ corresponds to a velocity of a little more than 4 meters. Forecasts based on this observation only are correct 62 times out of 100.

Temperature.—In general, the probability of rain increases with the temperature, but it presents for —3.5° C. a very evident minimum $\frac{22}{100}$, and for about —6.5° a secondary maximum of about $\frac{34}{100}$. For temperatures above —3.5° the probability increases at first rapidly, from 3° to 6° very slowly, and then rapidly again. It is $\frac{79}{100}$ for a temperature of 12°. In basing forecasts on temperature only, rain can be safely predicted at all times when the temperature exceeds 3°. This forecast will be correct 61 times out of 100.

Cloudiness.—At 9 o'clock in the morning, in winter, in Paris, the sky is completely covered 57 days out of 100; entirely clear 10 days out of 100. The intermediate degrees of cloudiness are much more rare. I combined them in two groups and obtained the following results: Percentage of probability of rain.—Cloudless sky, 12; cloudiness (0–4), 34; cloudiness (5–9), 52; sky covered, 52.

With these figures only as a basis, rain could be predicted whenever cloudiness was 5 or more. A forecast based on this probability would be correct 58 times out of 100.

Reviewing the percentage of probability of rain for each of the six elements, we see that the best criterion in forecasting is the direction of the wind; then come pressure, velocity of the wind, temperature, variation of pressure, and last, cloudiness.

If the figures of probability furnished by the various elements taken separately could be reduced to a common scale independently of each other, one would gain much in taking the average after having multiplied them by a factor proportional to their importance. In reality, these determinations are not independent; for instance, when the direction of the wind is southwest, the barometer is most often low and the temperature relatively high; these three elements tend, consequently, to give analagous indications, which do not correct one another. I have attempted to determine what proportion of success would be obtained by taking the mean of the statistics of probability furnished by the barometric height and the direction of the wind. This process, applied to 1546 cases observed, gives 70 per cent of correct forecasts. We have seen that 67 per cent of the forecasts based on direction of the wind alone would be correct. The gain is not considerable.

We do not increase the proportion of success in utilizing the six elements; it is decreased on the contrary in this case to 69 per cent. To explain this result, in appearance paradoxical, it is sufficient to remember the fact that the six determinations are not independent. The addition of four new elements to the first two (pressure and direction of wind) can tend to give too great a weight to one of these two elements and thus produce an unfavorable result. By giving the proper coefficient to each one of the six elements, one could probably raise the proportion of success a little, but after the attempts I have made I think it would not be possible to raise it sensibly above 70 per cent.

Probability of rain in combining two elements.—In the preceding, the probability sought has been determined in function of one element only, without regard to the values of the other elements. It is natural to think that in varying two elements at a time and calculating the probability of rain for the various combinations possible for these two elements, one would attain to greater accuracy.

One can conceive, for example, that the coincidence of a low pressure and a wind from the northeast, which is usually accompanied by a high pressure, would be susceptible of furnishing a much better forecast than that which one could deduce from a low pressure and a wind from the northeast, taken separately.

The elements considered in this work can be combined two by two in 15 different manners. Among these 15 different combinations, I have studied 9 which appeared the most interesting: Pressure and variation of pressure, direction of the wind and pressure, direction of the wind and variation of pressure, direction and velocity of the wind, direction of the wind and temperature, and, finally, cloudiness combined with pressure, with direction of the wind, with the variation of pressure, and with temperature.

For each of the first five groups, the numerical results furnished by statistics have been reduced to graphic representations of three coordinates, representing the curves of equal probability of rain, traced for each 10 per cent. For each of the groups where cloudiness is concerned four curves of two coordinates have been drawn, relative to the four degrees of cloudiness previously specified.

Contrary to what one might hope, they do not present a great advantage over the curves representing one element. Certain of them give less satisfactory results than the one element. For instance, the curve representing pressure and direction of the wind combined furnished only 69 correct forecasts out of 100. Now, we have seen that in taking the mean of the probabilities, deduced separately, of pressure and of direction of the wind, we will be correct 70 times out of 100. The inferiority of the curve of two elements results from the fact that there are so few cases of areas of very high and very low pressure occurring with each direction of the wind that it is impossible to deduce any rule to govern these conditions. One is thus obliged to consider the probability of rain in such cases as equal to $\frac{50}{100}$. Now, with the probability $\frac{50}{100}$, in only one case out of two could rain be safely predicted.

As to the curves representing only one element, they may be extended to the most extreme variations of the element, and the cases that escape their application are very rare. In the field of general utility the two processes give equivalent results; in fact, if we take the proportion of correct to incorrect forecasts, we find that the proportion is the same for both.

In spite of the slight inferiority which the graphics of two elements offer, taken separately, they constitute, when we combine them, a better means of forecasting than the curves of only one element. After having attempted nearly all the combinations possible, I recognized the fact that in order to attain the maximum proportion of success it is best to use all the graphics of two elements enumerated above, excepting that combining the direction of the wind and the temperature, the addition of which is detrimental. We take simply the arithmetical mean of the eight figures of probability, and according to whether this mean is more than 50 we forecast or do not forecast rain. This method gives 73 per cent of correct forecasts.

It happens quite frequently that among the eight figures of probability there is one higher than 73 or lower than 27; in this case, it would seem that one should base the forecast on this number rather than on the mean of the eight numbers. I am convinced that in reality one gains nothing in proceeding thus, no doubt because 73 per cent is only a mean value, systematically of too little weight in this particular case.

I thought it interesting to apply this method to last winter, which is not included in the data upon which these curves are based.

In the course of the winter it rained or snowed 17 times at 9 o'clock. There remained seventy-four days, for which the forecast was correct 57 times and incorrect 16 times; besides, the probability, 50 per cent, was obtained once. The proportion is 78 per cent. The variation between this result and the average result, 73 per cent, deduced from a long series of observations, shows that one should expect to see the proportion of success attained vary from year to year, which is not surprising in considering a question into which chance enters to a certain extent.

The average success of 73 per cent could be considered as fairly satisfactory, but it should be observed that the question, as it is stated, admits of great difficulty, in spite of the short period covered by the forecast. To avoid all arbitrariness, we have considered as rain the least fall of water or of snow, even when reduced to fine drops of drizzling rain. Now, we frequently observe in winter, according to the temperature, drizzling rain or small flakes of snow, even when the general condition is that of dry weather. By treating in the same manner the question as to whether an appreciable amount of rain will fall—for example, 1 millimeter—we will certainly attain a higher proportion of success.

Having determined the slight advantage obtained by calculating the probability of rain in function of two elements instead of one, one may question if it would not be advantageous to calculate the probability in terms of three elements or more. This method is altogether impracticable at the present time. In fact, in order to establish statistics of probability based on three elements at the same time, it would be necessary to divide the data into a number of groups about ten times greater than for two elements and consequently ten times more observations would be required to obtain the same precision. Now, our twenty-one years scarcely suffice to calculate the probability in terms of two elements. More than two hundred years of observations would thus be required to calculate the probabilities in terms of three elements.

I will point out, in closing, some particularly interesting facts brought to light by graphics of the two elements.

For all winds, excepting those blowing between the north and the west, rain presents a maximum of probability for a pressure of about 750 millimeters; for winds from the east-northeast this maximum is very marked and corresponds to 755 millimeters.

The increase of the probability of rain with the velocity of the wind is verified for all directions, but it is very slight for winds from the east-northeast and is most marked for those between south and west.

The probability of rain increases with the temperature for all directions, but only reckoning from a minimum which occurs at about —5° for winds from the south, and about —1° for winds from the north. For winds from the north, the temperature presents a maximum at 3° from which it decreases.

When the sky is clear or slightly cloudy, the probability of rain is minimum for a barometric rise of 0.1 millimeter from 6 to 9 o'clock, and *increases notably with the rise.* Thus, for cloudiness comprised between 0 and 4, the probability is only 25 per cent for a barometric rise of 0.1 millimeter and becomes 50 per cent for a rise of 2.25 millimeters.

These remarks have not a great practical importance in weather forecasting, but they present a certain interest from a general meteorological point of view.

NOTE BY PROF. E. B. GARRIOTT, CHIEF OF FORECAST DIVISION, U. S. WEATHER BUREAU.

The local signs of approaching weather changes, rain for instance, necessarily vary in different countries, and, in many instances, in different parts of a State. The whole proposition, in fact, places local observations in the same relation to the reports of a meteorological service that the reports of a